PART I - ADMINISTRATIVE

Section 1. General administrative information

Title of project

Stufa Participation In A Plan For Analyzing And Testing Hypotheses (Path)

BPA project number: 9600800
Contract renewal date (mm/yyyy): 11/1999 ☐ **Multiple actions?**

Business name of agency, institution or organization requesting funding
Oregon Department of Fish and Wildlife

Business acronym (if appropriate) ODFW

Proposal contact person or principal investigator:

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NPPC Program Measure Number(s) which this project addresses
3.2.A, 3.2.F , 4.2a, 4.3, 7.1E

FWS/NMFS Biological Opinion Number(s) which this project addresses
NMFS Hydrosystem BO RPA 13; RPA A17

Other planning document references
Multi-Species Framework Briefing Nov. 1998: Analytical Approach page 21, NMFS Recovery Plan task 0.3.b and 2.11.b

Short description
Test hypotheses underlying key salmon recovery management decisions, develop decision analysis to evaluate alternative management strategies, and assist in designing research, monitoring and adaptive management experiments.

Target species
Columbia Basin salmon and steelhead

Section 2. Sorting and evaluation

Subbasin
Columbia River Basinwide

Evaluation Process Sort

CBFWA caucus	Special evaluation process	ISRP project type
Mark one or more caucus	If your project fits either of these processes, mark one or both	Mark one or more categories
☒ Anadromous fish ☐ Resident fish ☐ Wildlife	☒ Multi-year (milestone-based evaluation) ☐ Watershed project evaluation	☐ Watershed councils/model watersheds ☐ Information dissemination ☐ Operation & maintenance ☐ New construction ☒ Research & monitoring ☒ Implementation & management ☐ Wildlife habitat acquisitions

Section 3. Relationships to other Bonneville projects

Umbrella / sub-proposal relationships. List umbrella project first.

Project #	Project title/description
20515	Mainstem Columbia River ODFW Umbrella Proposal (region umbrella)
9600600	PATH, Facilitation, Tech Assistance & Peer Review (programatic umbrella)

Other dependent or critically-related projects

Project #	Project title/description	Nature of relationship
98	PATH Participation NMFS	PATH scientific support
9303701	Simulation Modeling Participation C. Paulsen	PATH scientific support
8910800	Modeling PATH/ BPA technical support Univ. of Washingto	PATH scientific support
9203200	USFS modeling support	PATH scientific support
9601700	Hydrosystem Work Particiption A. Giorgi	PATH scientific support

Section 4. Objectives, tasks and schedules

Past accomplishments

Year	Accomplishment	Met biological objectives?
1996	For Snake River salmon clarify management decisions with senior personnel in the major management institutions	yes
1996	Develop hypothesis frameworks and sets of alternative hypotheses relevant to those management decisions	yes
1996	Perform data reconnaissance, acquisition and refinement prior to completion of retrospective analyses of specific hypotheses	yes
1997	For Snake River spring and summer chinook salmon perform detailed retrospective analyses for hypotheses related to hydrosystem, habitat, harvest and hatchery management decisions	yes and continued work for other species
1997	Through a series of five workshops involving about 30 research scientists plan retrospective and develop tools for prospective analyses, and reviewed the results of those analyses and their implications for management decisions	yes, for Snake River spring, summer and fall chinook working on steelhead and chinook from other parts of the Columbia River basin
1997	Develop new analytical tools (Bayesian probabilistic approach) to assist in decision making framework	yes, for Snake River spring, summer and fall chinook working on steelhead and chinook from other parts of the Columbia River basin
1998	Perform and document a Snake River Spring/summer chinook Decision Analysis for hydrosystem management alternatives	yes
1998	Produce and document weight of evidence for key alternative hypotheses which influence decision analysis results	yes
1998	Scientific Review Panel (SRP) charged with assigning weights to key alternative hypotheses and devloping recommendations for future PATH work	yes, for Snake River spring/ summer chinook
1998	Perform weighted decision analysis	yes, for Snake River spring/ summer chinook
1998	Perform and document a Snake River fall chinook Decision Analysis for	yes, preliminary decision analysis without acompanying weight of

	hydrosystem management alternatives	evidence approach
1998	Assessment of actions on Steelhead	yes, preliminary analysis
1998	Coordinate PATH work with other regional groups such as the Corps' DREW (economis analysis) and Decision Process Coordinating Group	yes

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Determine the overall level of support for the key alternative hypotheses, and propose other hypotheses and/or model improvements that are more consistent with existing data.	a	Complete retrospective analysis for upper Columbia River salmon and steelhead populations to support NMFS Biological Opinion in March, 2000, and analyses of stock rebuilding plans proposed by Multi-species Framework.
		b	Initiate retrospective analysis for lower Columbia River salmon and steelhead populations to support NMFS Biological Opinion in March, 2000, and analyses of stock rebuilding plans proposed by Multi-species Framework.
2	Advise regulatory agencies on management actions to restore endangered salmon stocks to self-sustaining levels of abundance	a	Complete prospective analyses for upper Columbia River steelhead and salmon populations
		b	Initiate prospective analyses for lower Columbia River steelhead and salmon populations
		c	Integrate findings of prospective/decision analyses of spring/summer chinook, fall chinook, and steelhead into overall evaluation of alternative management options.
3	Assess the ability to distinguish among competing hypotheses from future information, and advise agencies on research, monitoring, and adaptive management experiments that would maximize learning	a	Modify existing models and develop models to more efficiently evaluate experimental management options.

		b	Explore feasible range of experimental management options.
		c	Identify key monitoring needs and the evaluation approach to maximize learning under various experimental management options
		d	Assist in implemeting monitoring programs (for the 1999 decision) and evaluations which maximize learning for selected experimental management approaches

Objective schedules and costs

Obj #	Start date mm/yyyy	End date mm/yyyy	Measureable biological objective(s)	Milestone	FY2000 Cost %
1	11/1999	10/2000		task 1a complete	10.00%
1	11/1999	10/2000		task 1b complete	10.00%
2	11/1999	10/2000		task 2a complete	10.00%
2	11/1999	10/2000		task 2b complete	10.00%
2	11/1999	10/2000		task 2c complete	20.00%
3	11/1999	10/2000		task 3a&b complete	20.00%
3	11/1999	10/2000		task 3c complete	10.00%
3	11/1999	10/2000		task 3c initiated	10.00%
				Total	100.00%

Schedule constraints

Dependent upon prioritization of assignments by regional policy makers(eg. Executive Committee, Implementation Team); their assignments are influenced by many aspects of decision making process. Unexpected delay in run reconstructions and modeling.

Completion date

Unclear. Many agencies (NMFS, NPPC, CoE, ODFW, WDFW, IDFG, and USFWS) have identified an ongoing need for a coordinated, peer-reviewed, regional analytical work group.At least until 2004.

Section 5. Budget

FY99 project budget (BPA obligated): $698,778

FY2000 budget by line item

Item	Note	% of total	FY2000
Personnel	NRS4 10 mos, NRS3 8 mos, NRS2 8 mos, Manager 3 mos, Office Asst. 3mos	%15	111,871
Fringe benefits	41% of salary	%6	45,867
Supplies, materials, non-expendable property	Computer Software Miscellanous	%0	2,379
Operations & maintenance	Communications Computer Lease	%1	4,358
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		%0	
NEPA costs		%0	
Construction-related support		%0	
PIT tags	# of tags:	%0	
Travel	air fare, per diem, lodging, Mileage & Parking for workgroups and workshops	%1	4,426
Indirect costs	35.5%	%8	59,959
Subcontractor	Columbia Basin Fish and Wildlife Authority(CBFWA)	%15	110,965
Subcontractor	Columbia River Inter-Tribal Fish Commission(CRITFC)	%17	125039
Subcontractor	Idaho Department of Fish and Game(IDFG)	%16	115,500
Subcontractor	Washington Department of Fisheries(WDFW)	%16	122,046
Subcontractor	U S Fish and Wildlife Service (USFWS)	%6	42,721
Other		%0	
TOTAL BPA FY2000 BUDGET REQUEST			$745,131

Cost sharing

Organization	Item or service provided	% total project cost (incl. BPA)	Amount ($)
		%0	
		%0	
		%0	

		%0	
		Total project cost (including BPA portion)	$745,131

Outyear costs

	FY2001	FY02	FY03	FY04
Total budget	$745,500	$750,000	$787,500	$787,500

Section 6. References

Watershed?	Reference
☐	Barnthouse, L. (ed.), J. Collie, B. Dennis, S. Saila, and C. Walters. 1996. Plan for Analyzing and Testing Hypotheses (PATH): First Scientific Review Panel Report. Prepared by ChemRisk Division, McLaren/Hart Environmental Engineering Co., Oak Ridge, TN f
☐	Barnthouse, L. (ed.), J. Collie, B. Dennis, S. Saila, and C. Walters. 1997. Plan for Analyzing and Testing Hypotheses (PATH): Second Scientific Review Panel Report. Prepared by ChemRisk Division, McLaren/Hart Environmental Engineering Co., Oak Ridge, TN
☐	Beamesderfer, R.C.P., H.A. Schaller, M.P. Zimmerman, C.E. Petrosky, O.P. Langness, and L. LaVoy. in preparation. Spawner-recruit data for spring and summer chinook populations in Idaho, Oregon and Washington. July 1996 Draft Documentation for PATH - Pl
☐	Langness, O. P. and H. A Schaller. 1996. Contrasting Stock-Recruitment, Harvest, and Upstream Passage Survival Patterns of the Columbia River Stream-Type Chinook Populations. Draft Chapter 13 in: Plan for Analyzing and Testing Hypotheses (PATH),Retrosp
☐	Marmorek, D.P. and I. Parnell (eds.). 1995. Plan for Analyzing and Testing Hypotheses (PATH): Information package for Workshop 1 - Design of retrospective analyses to test key hypotheses of importance to management decisions on endangered and threatened C
☐	Marmorek, D.R, I, Parnell, L. Barnthouse and D.R. Bouillon. 1995. PATH - Plan for Analyzing and Testing Hypotheses. Results of a Workshop to Design Retrospective Analyses. Prepared by ESSA Technologies Ltd. Vancouver, BC for Bonneville Power Administratio
☐	Marmorek, D.R. (ed.)1996. Plan for Analyzing and Testing Hypotheses (PATH): Final report on retrospective analyses for fiscal year 1996. Compiled and edited by ESSA Technologies Ltd., Vancouver, B.C. 620 pp.
☐	Marmorek, D. and C. Peters (editors) and 24 co-authors. 1996. PATH - Plan for Analyzing and Testing Hypotheses. Conclusions of FY 96 Retrospective Analyses. Prepared by ESSA Technologies Ltd., Vancouver, B.C. for Bonneville Power Admin., Portland
☐	Marmorek, D.R. and C. Peters, editors. 1998a. Preliminary decision analysis report on Snake River spring/summer chinook, . Report compiled and edited

	by ESSA Technologies Ltd., Vancouver BC.
☐	Marmorek, D.R. and C. Peters, editors. 1998b. Weight of evidence report on Snake River spring/summer chinook. August 1998. Report compiled and edited by ESSA Technologies Ltd., Vancouver BC.
☐	Marmorek, D.R. and C. Peters, editors. 1998c. PATH Final Report for Fiscal Year 1998 (DRAFT). November 1998. Report compiled and edited by ESSA Technologies Ltd., Vancouver BC.
☐	Petrosky, C.E. and H.A. Schaller. 1996. Evaluation of survival trends in the freshwater spawning and rearing life stage for Snake River spring/summer chinook. Chapter 9.0 in: Plan for Analyzing and Testing Hypotheses (PATH). Final Report on Retrospec
☐	Petrosky, C. 1997. Steelhead data reconnaisance and run reconstruction. Progress Report for PATH Workshop 5. October 20-23, 1997. 5 p. plus tables and figures.
☐	Schaller, H.A., C.E. Petrosky and O.P. Langness. 1996. Contrasts in stock recruitment patterns of Snake and Columbia River spring/summer chinook populations. Chapter 3.0 in: Plan for Analyzing and Testing Hypotheses (PATH). Final Report on Retrospecti
☐	Toole, C., A. Giorgi, E. Weber, , W. McConnaha, and anonymous. 1996. Hydro Decision Pathway and Review of Existing Information. Chapter 6.0 in: Plan for Analyzing and Testing Hypotheses (PATH). Final Report on Retrospective Analyses for Fiscal Yea
☐	Wilson, P. and anonymous authors. 1996. PATH: Hatchery Impacts. Chapter 11.0 in: Plan for Analyzing and Testing Hypotheses (PATH). Final Report on Retrospective Analyses for Fiscal Year 1996. Prepared by ESSA Technologies Ltd., Vancouver, B.C. for Bonn
☐	Wilson, P., E. Weber, C. Petrosky and H. Schaller. 1997. Draft proposed general framework for prospective modeling with detailed examples for one hypothesis about delayed mortality. PATH document, submitted August 1, 1997.
☐	Wilson, P. and H. Schaller. August 1997. Passage and prospective model linkage. PATH progress report.
☐	PATH Scientific Review Panel. (Drs. S. Carpenter, J.Collie, S. Saila, C. Walters). 1998. Conclusions and Recommendations from the PATH Weight of Evidence Workshop. September 8-10, 1998. Edited by C. Peters, I. Parnell, D. Marmorek, R. Gregory, T. Eppel.

PART II - NARRATIVE

Section 7. Abstract

The NMFS 1995-1998 Biological Opinion on operation of the Federal Columbia River Power System created a process called PATH--Plan for Analyzing and Testing Hypotheses. The PATH process was designed to clarify the nature of differences among

salmon management models, and point the way towards helping to resolve them. The PATH process is intended to ensure that the region has the benefit of the best available scientific information in analyses supporting salmon recovery/rebuilding efforts, including: development of recovery plans for listed Endangered Species Act (ESA) salmon and steelhead populations; ESA section 7 consultations; and development of rebuilding programs under the Columbia Basin Fish and Wildlife Program. The first phase of PATH is retrospective and involves explicitly stating hypotheses about mortality over the life cycle, evaluating strengths and weaknesses of supporting evidence and testing those hypotheses which have significant management implications. Prospective analyses estimate the improvement needed in life cycle survival to achieve recovery objectives; forecast future stock responses for different management actions under the range of alternative hypotheses; document a biological rationale for each alternative hypothesis which can then be used in weighting in the formal decision analyses. The formal decision analyses assess the effects of different combinations of actions, to provide guidance to fishery management decision makers in an adaptive management framework. The experimental management approach should provide the region a tool to best implement management actions in order to minimize the risk to stock recovery while maximize the ability to learn. PATH's schedule and objectives are prioritized by needs for regional decision on the population recovery actions. The PATH products are rigorously reviewed by an independent scientific review team.

Section 8. Project description

a. Technical and/or scientific background

Salmon populations in the Columbia River Basin have been in decline since the early days of western settlement, with dramatic declines occurring in the last three decades. The annual production of the Snake River spring/summer chinook during the late 1800's was probably in excess of 1.5 million fish or 39% to 40% of all Columbia River spring/summer chinook (NMFS Biological Opinion, 1995). Today the population of Snake River spring/summer chinook is approximately 0.5% of its historic abundance, with approximately 1,800 spring/summer chinook returning to the Snake River. The story is similar for the Snake River fall chinook. From 1938, when Bonneville dam was completed, to 1950, the returns of Snake River fall chinook fell from approximately 72,000 to 29,000. Today, after completion of the Snake River dams approximately 350 Snake River fall chinook return. Such declines have led to both races of Snake River chinook being listed under the Endangered Species Act, though both have continued to decline since listing (NMFS, Proposed Recovery Plan for Snake River Salmon, 1995). Past efforts to halt the decline have been ineffective because 1) they didn't adequately reduce hydrosystem mortality; and 2) not all entities shared common objectives. A common adaptive management framework (analytical monitoring, evaluation and management assessment approach) for guiding research and monitoring activities and providing management advice for salmon population conservation and restoration, could have helped clarify these issues. The NMFS decision on the 1995 Biological Opinion for the FCRPS (hydrosystem) configuration and operations is slated for 1999. Therefore,

there is an urgent need for coherent, defensible biological guidance to decision makers.

PATH has made very significant progress in building constructive working relationships among scientists from agencies with different perspectives (i.e. BPA, NMFS, USACE, State and Tribal agencies, NWPPC). PATH has helped to define many areas of common agreement and is specifying the information or experiments needed to resolve remaining key areas of disagreement. The high quality retrospective analyses (Marmorek et al. 1996; Marmorek and Peters 1996), the prospective analyses (Marmorek and Peters 1997), the decision analysis (Marmorek and Peters 1998a), and the weight of evidence analysis (Marmorek and Peters 1998b,c,d) reports cooperatively, are building the foundation for evaluating recovery measures for Snake River salmon populations. This PATH work and the conceptual foundation provided by the ISG in their Return to the River report, will together strengthen the scientific basis for the difficult and urgent decisions that must be made for salmon conservation and recovery. In addition, the experimental management approaches proposed by PATH and the Scientific Review Panel should assist in assessing the effects of management actions in a manner that minimizes risks to populations while maximizing our ability to reduce uncertainties for key hypotheses. The PATH group has filled the role as a regionally coordinated analytical body for salmon and steelhead recovery measure evaluations.

b. Rationale and significance to Regional Programs

Snake River spring/summer and fall chinook, steelhead, and sockeye populations have declined dramatically since completion of the Federal Columbia River Power System (FCRPS). Snake River spring/summer and fall chinook are listed as threatened under the Endangered Species Act (ESA), and sockeye are listed as endangered. Steelhead in the Snake and upper Columbia rivers are listed as threatened. Under the ESA, the National Marine Fisheries Service (NMFS) is charged with developing and implementing management plans to ensure survival and recovery of the listed salmon populations.

For the past several years the various federal, state, and tribal resource agencies have been attempting to work together to compare and enhance the models used by all of the agencies to evaluate management actions intended to recover depleted Columbia River Basin salmon stocks. Results from previous model comparison and peer-review efforts indicated that the models operate with different interpretations or hypotheses regarding the survival rates at different stages of the salmon life cycle, and result in disparate management advice.

The NMFS' 1995-1998 Biological Opinion on operation of the FCRPS created a process called PATH--Plan for Analyzing and Testing Hypotheses. The PATH process was designed to clarify the nature of the differences among the models and point the way towards helping to resolve them (Marmorek and Parnell 1995). The region has a continuing need to consider analytical results in decision making in a number of areas, including: the development of specific recovery plans for listed salmon and steelhead

stocks; the Endangered Species Act mandated Section 7 consultation process; the development of rebuilding programs under the NWPPC Fish and Wildlife Program (see sec. 2.2-4 Strategy for Salmon Vol. II); and the Multi-Species Framework initiative (Development of a Framework for Columbia River Basin Fish and Wildlife Policy). The region has and will continue to benefit significantly in these areas from a coordinated and consistent approach to technical analyses supporting salmon rebuilding and recovery efforts. In recognition of the need, the NWPPC (Ibid., Sec. 7.3) has called for "....a process to provide for continuing review, coordination and development of analytical tools to assist decision making, facilitate program evaluation and identify critical uncertainties." The PATH process is intended to ensure that the region has the benefit of the use of best available scientific methods and information in the analyses supporting salmon recovery/rebuilding efforts.

The first phase of PATH is retrospective, and involves explicitly stating hypotheses about the distribution of mortality over the life cycle, evaluating strengths and weaknesses of supporting evidence, and testing those alternative hypotheses which have significant management implications. Hypotheses are organized within PATH by anthropogenic (habitat, harvest, hatcheries and hydropower) and environmental (climatic/oceanographic) factors. The hypothesis and decision frameworks we developed and applied in PATH have provided a means of harnessing a wide array of information, analytical tools and unpublished scientific knowledge towards key management decisions. The analyses have clearly confirmed patterns of spatial and temporal change in spring-summer chinook stocks, which not only elucidate the most likely causes of recent declines, but also lay the groundwork for grouping stocks for future adaptive management experiments. By bridging across different types of data sets and studies (e.g. migration corridor survival, transportation effectiveness, spawner-smolt survival, spawner-recruit survival, climate and ocean indicators, land use and hatchery indicators), PATH has generated a higher level understanding of how to integrate across life history stages and spheres of management action (hydro, hatchery, habitat, harvest). This provides a concrete foundation for designing adaptive management programs and coordinating research initiatives. PATH scientists have recommended several research, monitoring and evaluation approaches to resolving critical uncertainties (e.g. assessing the magnitude of delayed mortality of both transported and in-river migrants). In addition, by rigorously assessing the value of additional information from research studies, monitoring, and adaptive management experiments, PATH will provide a scientific basis for assisting in prioritizing expenditures for conserving and restoring these populations given limited financial resources. The design of this experimental management framework is already in progress: it is being driven by the management questions of interest, the alternative hypotheses relevant to these questions and the data available to test these hypotheses. In FY 1999 PATH is conducting a workshop on experimental management options and a preliminary analysis. The PATH scientific review panel has recommended that in light of the major uncertainties that are difficult to resolve with current information, we focus attention on experimental management options which vary management actions over time and space in a deliberate attempt to test key hypotheses pertaining to response of fish populations. Then design monitoring and evaluation programs for the various management options which minimizes risks to

populations while maximizing our ability to reduce uncertainties for key hypotheses. This process can be implemented through simulation modeling techniques. The experimental activities in FY 2000 will revolve around implementing monitoring programs and designing evaluations associated with management decisions in 1999.

Additional salmon and steelhead stocks have been listed or petitioned for listing in the upper and lower Columbia River baisn. The region is planning on PATH to provide the coordinated analytical efforts, for these populations, similar to Snake River population assessment approaches.

The region is committing resources to developing a framework for Columbia River Basin Fish and Wildlife policy through the Muti-species Framework initiative. The framework is intended to help policy-makers choose among fish and wildlife recovery strategies with an understanding of how their choices may affect a web of interacting species and environments; guide the allocation of fish and wildlife funds; and establish yardsticks with which to measure progress. . The framework must include coherent goals, objectives and strategies that are linked by a scientific foundation. Goals describe the broad purpose of fish and wildlife recovery. Ecological objectives describe the biological and physical conditions needed to achieve the goals. Strategies describe the types of actions needed to achieve ecological objectives. A scientific foundation underlies and helps connect the goals, ecological objectives and strategies. Through the scientific foundation, goals shape ecological objectives, which shape strategies. Following the development of a scientific foundation, it is anticipated that a series of landscape-level assessments would be needed to develop a framework. These assessments would utilize existing information whenever possible. Ongoing or completed regional efforts such as the PATH can provide a considerable amount of information and analysis that could be used to formulating a regional framework. It is anticipated that a scientific team would be asked to provide an analysis of alternative strategies**.** This would characterize the ecological conditions implied by the biological vision and constraints developed by the policy group, describe the types of strategies that might achieve these ecological conditions, and the ecological risk associated with each alternative. It is being planned that the team would be assisted in this by quantitative, population-based analysis of the alternatives by PATH.

c. Relationships to other projects

Increasing the returns and diversity of salmon and steelhead populations to the Columbia River basin relies on activities throughout the subasins, mainstem corridors, estuary, and ocean. The PATH project is a coordinated and consistent approach to technical analyses supporting salmon rebuilding and recovery efforts over the life-cycle. This project coordinates these efforts for three state agencies, four tribes and the USFWS. The project is integrated on a programmatic level through the PATH facilitation contract with ESSA. The PATH project coordinates the activities of 25-30 scientists working on analyses of salmon rebuilding and recovery alternatives. PATH currently involves cooperation among scientists from NMFS, BPA, U.Washington, NPPC, ODFW, IDFG, WDFW,

CRITFC, USFS, USFWS, CBFWA, USACE, as well as from a number of independent representatives from academic and research institutions (Simon Fraser University, UC Davis, UBC, U. Rhode Island, U. Wisconsin, Inter-American Tropical Tuna Commission) and private firms (ESSA Technologies, Paulsen Environmental Research, Don Chapman Consultants). Collaboration occurs through workshops, meetings, workgroups, cooperative planning, joint reports, and scientific review. In addition, the Independent Scientific Advisory Board has participated in PATH since its inception (Phil Mundy, Dan Goodman, Chuck Coutant, and Chip McConnaha,). Close cooperation with the ISAB is very important to PATH. PATH provides a formal process to efficiently utilize and focus the regional technical expertise. The PATH work will also be coordinated with US vs Oregon Columbia River Fish Management Plan activities and the Mid- Columbia Habitat Conservation processes. The PATH project provides better integration of decision making among management agencies through a clear framework for decision analysis and adaptive management experiments. The PATH project directly links and coordinates the work of 7 Bonneville fish and wildlife program projects (identified in section 3 of the proposal).The relationships of direct PATH coordination with other BPA projects are identified in section 3. The integration of these projects by the umbrella facilitation project and the independent scientific review by the SRP have been key to the past successes and acceptance of PATH products.

Another key to coordinated and consistent approach to technical analyses is the collection of data. This project relies on the continuation of numerous data collection activities throughout the Columbia River basin. These activities include many BPA funded activities such as: Smolt Monitoring program, Northern Pikeminow program and predator control assessment, Comparative Survival Studies, NMFS Reach Survival studies, Spawning escapement enumeration projects, Coded-Wire-Tag (CWT) marking and recovery, and StreamNet data services. These activities also rely on data collected through Pacific Salmon Treaty activities (CWT mark and recovery, and escapement enumeration), US Army Corp projects(dam counts, transportation experiments), and US vs Oregon-Columbia River Fish Management Plan activities.

d. Project history (for ongoing projects)

PATH began in 1995. In 1993 and 1994, funding was provided to facilitate cooperative efforts by the BPA, the NWPPC, the NMFS, IDFG, ODFW and WDFW and the CRITFC and their member tribes to compare and enhance the simulation models they use to evaluate Columbia River salmon management options. Results from these model comparison activities and associated peer-review efforts showed that each modeling system has different strengths and weaknesses, several common patterns of model behavior, and some significant differences. In 1994, an independent scientific review panel (coordinated by Dr. Larry Barnthouse, then of Oakridge National Laboratory) completed an interim report in which they concluded that there were three major differences between modeling systems: 1) the distribution of survival over the life span; 2) the effect of flow on juvenile salmon survival; and 3) the benefit of transporting juvenile salmon around hydroelectric dams. The panel felt that as long as these

differences exist the models were going to give different answers in a fairly predictable fashion. This would result in conflicting advice to decision makers and would make further analysis of details of model behavior relatively unproductive. The panel concluded that it would be more fruitful to focus on describing and attempting to resolve the fundamental issues, through hypothesis formulation and testing (applying Bayesian and other approaches). The 1995 NMFS Biological Opinion on operation of the federal Columbia River Power System (pg. 124, Rec. 17) stated that "The BPA shall participate with NMFS in activities to coordinate the regional passage and life cycle models and to test the hypotheses underlying those models." NMFS noted that the emphasis should shift to analyses that test the different assumptions underlying the models, rather than refining our understanding of how the models are different. NMFS concurred with the recommendation of the Scientific Review Panel (SRP) to conduct an analysis of alternative hypotheses, and worked with BPA to ensure that this work was funded out of the dollars dedicated to actions arising out of the Biological Opinion. This was the genesis of the Plan for Analyzing and Testing Hypotheses (PATH). Critical to the success of PATH are three components: 1) facilitation and funding of the interagency scientific working groups, 2) specialized expertise in Bayesian statistics, multivariate analysis, and Columbia Basin salmon stock assessment and population dynamics; and 3) external, independent peer review.

In the 4 years of its existence, PATH has already made considerable progress. Specific achievements include:

- clarification of management decisions with senior personnel in the major institutions;

- development of hypothesis frameworks and sets of alternative hypotheses relevant to management decisions;

- considerable data reconnaissance, acquisition and refinement prior to completion of retrospective analyses of specific hypotheses;

- detailed retrospective analyses for hypotheses related to hydrosystem, habitat, hatchery and harvest management decisions;

- a number of workshops, each involving about 30 research scientists, to plan retrospective, prospective, and decision analyses, review the results of analyses through a weight of evidence process and assess their implications for management decisions;

- a series of technical meetings of task work groups to advance progress on specific retrospective analyses;

- novel development and/or application of analytical tools to assist in decision making

1. three-level hypothesis framework

2. decision trees for hydrosystem, habitat and hatchery management decisions

3. a Bayesian maximum likelihood estimation (MLE) framework to evaluate ability of different models to predict stock-recruitment patterns

4. several different statistical analyses (cluster analyses, multiple regression, analysis of variance and covariance) to assess patterns implied by spatial and temporal contrasts in stock-recruitment

5. a method for evaluating survival trends in the freshwater spawning and rearing life stage

6. prospective analyses for determining the required improvements in the chinook salmon life cycle survival needed for achieving recovery goals

7. development of a Bayesian population model to be used to simulate the implications of habitat, harvest, hatchery, and hydro management actions for survival and recovery of listed Snake River spring/summer chinook stocks

8. a formal decision analysis to assess, through a variety of performance measures, the effects of different combinations of actions in each of the four H's (hydrosystem, hatcheries, habitat, harvest]

- numerous reports (see below)

- a 30-page Conclusions Document synthesizing the major findings from the 620-page Final Report on Retrospective Analyses for FY96, including outstanding information needs necessary to resolve major uncertainties

- Decision analysis report (Marmorek and Peters 1998a) on spring/summer chinook which tests the decision analysis formulated over the last two years, provides decision makers with our preliminary insights into the range of population responses to alternative management decisions, provides biological rationale for alternative hypotheses, and characterizes the magnitude of uncertainties and demonstrates their

relative importance in affecting outcomes of alternative management decisions.

- A Weight of Evidence process and report (Marmorek and Peters 1998b) on spring/summer chinook which; identified effects of key uncertainties on management outcomes; assessed the evidence for and against alternative hypotheses for these key uncertainties; and SRP review evidence, identify key hypotheses, and assign weights to key alternative hypotheses. The purpose of the weight of evidence process is to use expert judgement (SRP) to assess the relative degree of belief in key alternative hypotheses and to evaluate the effects of management actions on the performance of chinook populations using these relative beliefs.

- Preliminary Decision analysis for Snake River fall chinook and qualitative assessment of the effects of actions on Snake River steelhead and sockeye salmon (Marmorek and Peters 1998c).

- a set of presentations on progress by PATH participants to the Implementation Team (IT) Committee on PATH and other IT representatives; members of the NPPC , state fish and wildlife commissions, and the public; meetings with the Decision Process Coordinating Group of the IT; and meeting with the Independent Scientific Group (now the Independent Scientific Advisory Board) to coordinate our activities.

The past costs for this project were $498,598 for 1996, $606,381 for 1997, $633,331 for 1998, and $698,778 for 1999.

e. Proposal objectives

Objectives

The goal of this contract is to have the state, federal, and tribal fishery agency participants provide technical assistance in completing PATH tasks. Particularly, in the areas of run reconstruction, retrospective stock assessment, juvenile migration models, decision analysis design and modeling, experimental management modeling and design, and report writing. Also, to participate in coordination activities through the PATH planning group.

The primary objectives were originally defined as:

1. Determine the overall level of support for key alternative hypotheses based on existing information (the greater the number and diversity of confirming observations, the more probable the hypothesis). Use these results to provide

guidance to management agencies. Propose other hypotheses and/or model improvements that are more consistent with the data.

2. Advise regulatory agencies on management actions to restore endangered salmon stocks to self-sustaining levels of abundance.

Sub-objectives for Objective 2:

- define the management decisions that serve to focus analytical activities;
- improve existing model and/or develop new models to better evaluate the likelihood of persistence and recovery of salmon and steelhead stocks (i.e. assess conservation risk) under alternative management scenarios;
- provide guidance to the development of regional programs that would stabilize, ensure persistence of, and eventually restore depressed salmon stocks to self-sustaining levels;

3. Assess the ability to distinguish among competing hypotheses from future information. Advise various institutions on research, monitoring and adaptive management experiments, which would maximize the rate of learning and clarify decisions.

Sub-objectives for Objective 3:

- provide guidance to managers on the strategic implications of hypotheses tests for key management decisions, and for the design of research, monitoring and adaptive management experiments that maximize the rate of learning and clarity of decisions; and
- provide a structure for an adaptive learning approach to development and implementation of a regional salmonid recovery program (i.e. iterative evaluation of results of research, monitoring, and adaptive management experiments; assess implications of alternative hypotheses on subsequent actions).

Further thinking has led to an evolution in PATH's objectives and the means of achieving them. PATH is an iterative process of defining and testing a logical framework of hypotheses relating to the Columbia River anadromous salmonid ecosystem, while moving towards stock recovery and rebuilding. Iterations within the PATH process should occur as this logical framework is revised over time in response to improvements in both information and analytical methods. The logical framework developed in PATH will assist in management decisions concerning the Columbia Basin anadromous salmonid ecosystem. The design of this framework is driven by the management questions of interest, the alternative hypotheses relevant to these questions, and the data available to test these hypotheses. The purpose of the exercise is not to simply compare the existing belief systems embodied in the various models, though modeling plays a large role. Instead, the framework that is laid out is not limited to existing models. Ultimately, this should also lead to improvements in analytical tools.

In going through prioritization of FY1999 tasks for PATH with the IT, it appears not all proposed tasks can be completed in FY1999. Therefore, the FY 2000 proposal includes a number of FY1999 tasks prioritized by the IT to be completed in 2000.

Under objective 1 , PATH will devote considerable time to evaluating upper and lower Columbia River salmon and steelhead populations using techniques applied to Snake River populations. The PATH proposal in FY 2000 will shift focus from Snake River chinook and steelhead populations to evaluations of all chinook and steelhead populations of the upper and lower Columbia and Snake rivers. PATH will complete retrospective analysis for upper Columbia River salmon and steelhead populations. Develop a retrospective analysis for selected lower Columbia River salmon and steelhead populations.

Under Objective 2, Path will perform a prospective/decision analysis for upper Columbia River steelhead and salmon populations. Incorporate additional management actions proposed for these populations by the IT. Document the biological rationale for alternative hypotheses. Subject hypotheses to a weight of evidence process similar to that used for Snake River spring/summer chinook. Perform a preliminary prospective/decision analysis for selected lower Columbia River steelhead and salmon populations. Integrate findings of prospective/decision analyses of spring/summer chinook, fall chinook, and steelhead (from upper and lower Columbia and Snake rivers) into overall evaluation of alternative management options.

Under objective 3, PATH will focus on the analytical evaluation techniques needed to assess experimental management options in terms of risk to the stocks versus amount of learning possible. PATH will evaluate experimental management options across populations (e.g. spring/summer, fall chinook, and steelhead in the Columbia River basin). Using results from experimental management evaluation, develop a research, monitoring, and evaluation plan to support the 1999 decision management approach and other regional decisions.

The species will benefit by PATH providing the techniques to implement an experimental management approach that will minimize risk to population rebuilding and at the same time maximize learning. The retrospective analysis and Weight of Evidence process completed by PATH have made considerable progress in reducing both the magnitude and number of remaining uncertainties. Despite considerable progress, much uncertainty remains. Forecasts of future results of management actions are uncertain due to complex ecological responses to human and natural disturbances, variability over space and time, and incomplete knowledge of these ecosystems. These uncertainties create biological risk in our predictions of management actions, which have economic and social consequences. Using the existence of remaining uncertainties as a rationale for maintaining status quo management, is an approach that has an extremely low likelihood of achieving population recovery goals. The decision analysis approach under taken by PATH explicitly and quantitatively considers the implications of uncertainties, so as to provide the support to informed management decisions. A further improvement on the decision analysis approach taken to date is to choose those actions that will achieve a

given recovery objective, as well as learn something to improve future management. This is called experimental or adaptive management. The best experimental management approach to resolving uncertainty is called "active adaptive management" (Walters 1986). In an active adaptive approach, resource managers implement deliberate experimental changes to a system to provide the contrast necessary to test or refine the uncertainties about key hypotheses.

In past reviews of PATH products, the Scientific Review Panel (SRP) has commented repeatedly on the need for an experimental management approach to resolving major uncertainties. The FY 2000 PATH proposal, under objective 3, will focus on three main areas the SRP recommended:

1. Decision-making under uncertainty and the need for experimental management.

The weights assigned by SRP members to the key uncertainties reflect the relative likelihood of the alternative hypotheses, based on the evidence currently available. However, all SRP members commented that in some cases, the empirical evidence on which to evaluate alternative hypotheses was poor or lacking. This is because many events have occurred outside of the temporal and spatial range of historic monitoring programs, and outside of our experience. **However, the SRP strongly cautioned that uncertainty should not be used to justify either delaying action or taking no action at all.** Such a misuse of uncertainty in decision-making is not an acceptable component of responsible fisheries management (see United Nations Precautionary Approach). Instead, the SRP noted that the existence of uncertainties points to the need to take actions that result in the best chance at survival and recovery of stocks, and generate information to reduce uncertainties. Carefully designed and implemented experimental management actions to provide that opportunity are the objective of PATH.

2. Options for experimental management actions.

The SRP identified three major potential factors amenable to experimental management: hydrosystem effects, hatchery effects, and transportation effects. This suggested three possible manipulations: dam removal, elimination or substantial reduction of hatchery releases, and transportation turn-off. Implementing these actions in a well-designed experimental fashion can provide stronger evidence for the relative effects of each factor.

The SRP evaluated two strategies for implementing these actions. Both strategies are likely to require several decades to detect shifts in stock performance because of the high degree of natural variability in these measures.

i) Incremental alternative: implement the cheapest action first and monitor effects, then progressively more costly ones. This strategy requires the lowest up-front costs. However, it is the more risk-prone of the two strategies, because more effective actions are delayed if the cheapest action fails to produce the desired response in fish stocks. It may also be the higher-cost option in the long-term, if mitigative actions are required as each treatment is assessed. The incremental approach characterizes past management in the Columbia River.

ii) "Reverse staircase" alternative: Implement all actions at once, then turn dams, hatcheries, or transportation back on one at a time. This is a more risk-averse approach than the incremental approach and is more likely to lead to stock recovery, but involves larger up-front costs. Long-term costs depend on the costs associated with reversing the experimental actions (i.e. replacing dams, turning hatcheries and transportation back on).

PATH will work with regional managers to identify management options for evaluation.

3. Tools for evaluating experimental management options.
Experimental management actions can be evaluated by assuming some underlying response, then simulating the effects of the action to see if they are able to detect the assumed response. Here, the change in Recruits/Spawner is the crucial observation to distinguish among the hypotheses (Transport:control ratios should also be monitored for differential effects of hatcheries on transported vs. non-transported fish). The SRP made the following suggestions for evaluating experimental management options.

Evaluation of experimental actions will require a much simpler set of hypotheses and models than those used in the current PATH analyses. Hypotheses should focus on the expected response of R/S to an experimental action. Models used in evaluating experimental management actions need only to be able to predict changes in R/S in response to the experimental actions, under different hypotheses about the responses of R/S to the experimental treatment, while removing the effects of other factors on R/S. Density-dependent spawner effects, common year effects, and the main in-river survival effects of lower dams should be factored out.

The last of these components, in-river survival effects of lower dams, will require some form of passage model. However, SRP members felt that the existing passage models were too complex, time-consuming, and inflexible for exploring experimental management options. They recommended that a simpler passage model be used instead. This might be a simplified version of FLUSH and CRiSP, or a simple proportional relationship between mu (overall survival) and water travel time, as was tested in Ch. 5 of the Retrospective Report.

The purpose of the experimental management is to proceed with management actions in a manner designed to maximize the rate of learning about key uncertainties, while at the same time meeting survival and recovery objectives for salmon and steelhead populations throughout the Columbia River basin. PATH will provide guidance on what type of management experiments are worth pursuing through three steps: 1) define ability of experimental management option to reach population rebuilding goals and what it is we want to learn; 2) assess what we can learn from continued monitoring, retrospective analyses, and or research with status quo approach; and 3) contrast this with what we can learn using an active experimental management approach. That is PATH will explicitly document why reducing uncertainty about a particular hypothesis requires an active adaptive management approach, why further large management changes are required, and

why more passive approaches to learning are not adequate or pose a high level of risk to the populations.

It is anticipated that PATH would assist the science team of the Multi-Species Framework initiative with quantitative assessments of alternative strategies. This activity would fall under objectives 2 and 3. The Implementation Team also wants to rely on PATH as a common analytical workgroup to provide assessments as needed in FY2000.

f. Methods

PATH consists of an iterative series of workshops, analytical activities and reporting steps to test key hypotheses underlying management decisions, coordinated by an interagency PATH Planning Group. (The PATH Planning Group includes the PATH facilitator, David Marmorek (ESSA Technologies); H. Schaller, ODFW (representing the State fishery agencies); J. Geiselman, BPA (representing the power system operating agencies); C. McConnaha, NPPC; E. Weber, CRITFC; and C. Toole, NMFS.) The workshops and reports force participants to complete tasks, and provide for fruitful exchange, feedback and internal peer review. Both a core set of 25 PATH participants, and an extended set of 15 - 20 occasional participants, provide input to analytical activities. Interaction with the Implementation Team for the Draft Recovery Plan and NPPC helps to prioritize major goals.

Iteration within the PATH process occurs as the logical framework of hypotheses is revised over time in response to improvements in both information and analytical methods. This framework is intended to:

1. compile and analyze information to assess the level of support for alternative hypotheses relevant to key management decisions, identifying knowledge and data gaps that could be filled through management experiments, research and monitoring;
2. provide guidance to the development of regional programs that would stabilize, ensure persistence, and eventually restore depressed salmon stocks to self-sustaining levels; and
3. provide a structure for an adaptive learning approach to development and implementation of a regional salmonid recovery program.

The overall PATH process has five features to ensure high quality outputs: 1) fisheries scientists from the participating agencies; 2) active participation of three internationally recognized independent fisheries scientists in PATH workshops and technical meetings (Drs. Peterman, Deriso and Botsford); 3) the formation of interagency work groups to address specific topics, which ensures strong internal review of all work products; 4)

overall coordination, mediation and integration by the PATH facilitator; and 5) external review by the Scientific Review Panel (Drs. Walters, Collie, Saila ,Kitchell, and Carpenter).

PATH activities in FY96, 97, 98 culminated in the completion of a series of documents, which summarize the findings of retrospective analyses, prospective analysis, decision analysis, and weight of evidence process. These documents represent the consensus view of PATH participants on what the data and analyses, completed thus far, say about probable reasons for the decline in abundance of Snake River spring/summer chinook and the relative effectiveness of management alternatives. These documents have been supplemented by a series of presentations to the NPPC, the Implementation Team, state and tribal fish and wildlife commissions, and the public. Summary outputs and quarterly presentations are an integral part of the PATH process and are an important means of communication between PATH and interested groups in the region. PATH products are also available on the BPA-maintained www site.

Some of the technical methods used to date in PATH were summarized in the section on historical information. PATH uses a weight-of-evidence approach to hypothesis testing, looking for consistency across all available evidence, and the sensitivity of conclusions to the weights assigned to different data sources and analytical results. The retrospective analyses provide the foundation for prospective analyses. The goals for the prospective analyses are as follows:

P1. Estimate the improvement in life cycle survival required to reach various salmon objectives (survival, recovery, rebuilding) and the uncertainty associated with these estimates, using a Bayesian modeling approach that incorporates all uncertainties. These survival improvements can be expressed as Biological Objectives, consistent with the 1994 NPPC Fish and Wildlife Program. To develop goals for rebuilding, decisions will need to be made on which stocks are included. For survival and recovery goals these are clearly related to stocks listed under the *Endangered Species Act*.

P2. Develop a formal decision analysis framework, which provides a common tool for incorporating alternative management action packages, alternative states of nature (with their respective posterior probabilities based on retrospective analyses), and a variety of performance measures. The decision analysis framework will permit the calculation of the expected value of various performance measures (e.g. probably of survival, probability of recovery, expected rates of learning), given a number of different hypotheses about key processes, and their associated probabilities. In some cases (e.g. hydro) these probabilities may be computed from retrospective analyses, whereas in other cases (habitat, hatcheries) they may need to be more subjectively assigned (although bounded by inferences of empirical stock performance). The development of a suite of performance measures will involve interaction with the IT and

ISAB. Development of a set of action packages for the decision analysis will involve interaction with the IT as well as other entities. A modular set of interacting software tools is expected to evolve within this task to permit all PATH investigators to flexibly explore the implications of alternative model formulations. This modular framework would include the output from different passage models; tests of this output against both stock-recruitment, SARs, passage survival, and transportation studies (using an MLE framework to estimate Bayesian posterior probabilities); and a decision analysis tool to generate expected values of different performance measures given the model output and associated probabilities.

P3. Use of the decision analysis approach and other methods to assess the rate of learning associated with alternative sets of management actions, research and monitoring activities, and adaptive management experiments. This analysis of the benefits of different management and research directions would be linked to ongoing research, monitoring and evaluation programs, guide management decisions to minimize risks to extremely depressed populations, to assess how existing activities could be modified to better answer key uncertainties, and also to suggest new activities which could be added to those already planned. A component of this objective is to define performance measures to optimize the likelihood of reaching survival improvement objectives.

Tasks P1 and P2 were completed in FY97 and 1998 for Snake River spring-summer chinook. Retrospective analysis for fall chinook and steelhead will be completed in FY98, though more qualitative assessments will certainly occur in FY98. Experimental management work for spring-summer chinook will be initiated in FY99. Prospective modeling and decision analyses for fall chinook and steelhead will be completed in FY99. Prospective modeling, decision analysis, and experimental management design work integrating all three species will be undertaken in FY99 and 2000. These techniques will be applied to lower and Upper Columbia steelhead and salmon populations in FY2000. Integrating decision analysis and experimental management activities for Snake, upper and lower Columbia River anadromous salmonid populations will be initiated in FY 2000. These analytical assessments will be integrated with the Multi-Species Framework Initiative assessments in FY99 and 2000.

This work would continue through the year 2004 focusing on integrating these analyses and decision tools over many of the salmon populations in the Columbia River basin. This is the period where many critical management decisions and assessments of those decisions must be made.

g. Facilities and equipment

The project is primarily located at the following: CBFWF, Portland; CRITFC, Portland; IDFG, Boise; ODFW, Portland; USFWS, Vancouver; and WDFW, Vancouver. The State, tribal, and US fishery agencies (STUFA) staff shall participate in meetings of the PATH, ANCOOR and policy group in various locations. In addition, numerous technical work sessions will be required with technical representatives of STUFA, Facilitator, other ANCOOR member organizations, and outside technical experts to complete contract tasks. Periodically, STUFA representatives will need to consult and meet with their department field and research staff and attend related workshops and conferences. Some STUFA members will participate in Multi-species framework meetings, Decision Process Coordinating Group meetings, IT meetings, Pacific Salmon Treaty meetings, and activities to provide input from the PATH process. Also, STUFA members will periodically present findings to scientific associations.

h. Budget

The increase in the FY 2000 budget over the FY 1999 costs reflects the following: an increase of indirect costs for ODFW federal contracts, a 5% cost of living increase, and a slight increase in operational costs.

Section 9. Key personnel

Name: Howard Schaller
Title: Biometrics Program Leader NRS4
Project Position: Principle Investigator, project coordinator, technical representative for Oregon, stock assessment, and analytical support
Project tasks PATH planning group participation, project coordination, stock assessment, Oregon stocks run reconstruction, life-cycle modeling, statistical analyses, harvest analysis, hypothesis formulation and testing, decision analysis, and report writing.
Participation: FTE: .83 FTE (1733 hrs)
Education:
B.S., Biology, York College, City University of New York (1975)
M.S., Marine Science, C.W. Post Center, Long Island University (1980)
Ph. D., Oceanography (Fisheries), Old Dominion University (1984)
Current Employer: Oregon Department of Fish and Wildlife 1990-Present. Biometrics Program Leader in the Interjurisdictional Fisheries Management Program Primary Duties: develop analytical models and statistical procedures to assess, monitor, and describe factors limiting naturally produced fish populations. These analytical techniques incorporate and integrate ecology, conservation biology, and population dynamics principles using probabilistic approaches. Participate in an inter-agency modeling and hypotheses testing technical team for Columbia River Basin salmon recovery and rebuilding activities. Develop proposals and/or oversee a number of projects including: multi-state agency and tribal participation in PATH process; the lower Snake River Compensation Plan: chinook salmon population viability assessment; StreamNet data base project; and hatchery spring chinook PIT tag mark-recapture survival assessment.
Previous Employment: August 1990. Senior Fisheries Scientist for the Columbia River Inter-Tribal Fish Commission (CRITFC), Portland, Oregon. Primary Duties: Co-Chair of the Pacific Salmon Commission's (PSC) Chinook Technical Committee. Responsible for developing analyses to evaluate the impacts of long and short-term coastwide fishing proposals on the coastwide chinook salmon rebuilding program. August 1982 - April 1984. Co-principal investigator for the Prince William Sound (PWS) Salmon Management Study. Employed by the Department of Oceanography, Old Dominion University, Norfolk, Virginia.

Description of expertise: 15 years experience in modeling salmon population dynamics and assessing rebuilding and recovery programs. Developing analytical models and statistical procedures to assess, monitor, and describe factors limiting naturally produced fish populations.
Recent Publications:

Chinook Technical Committee. 1985-1990. Pacific Salmon Commission Joint Chinook Technical Committee Annual Reports 1985-1990. PSC Vancouver, B.C.

Debrot, A, H. Schaller, and M. Matylewich. 1989. Estimates of sustainable exploitation rates for Columbia River landlocked White Sturgeon: Evaluating the importance of a maximum size limit. Columbia River Inter-Tribal Fish Commission Technical Report 89-4.

Petrosky, C. and H. Schaller. 1992. A comparison of productivities for Snake River and lower Columbia River spring and summer chinook stocks. American Fisheries Societies 1992 Northwest Pacific Chinook and Coho Workshop Proceedings.

Petrosky, C.E. and H.A. Schaller. 1996. Evaluation of survival trends in the freshwater spawning and rearing life stage for Snake River spring/summer chinook. Chapter 9.0 in: Plan for Analyzing and Testing Hypotheses (PATH). Final Report on Retrospective Analyses for Fiscal Year 1996. Prepared by ESSA Technologies Ltd., Vancouver, B.C. for Bonneville Power Administration, Portland, OR. September, 10, 1996

Schaller, H. A, C. E. Petrosky, and O. P. Langness. 1997. Contrasts in stock-recruitment patterns of Snake and Columbia River spring and summer chinook salmon (Oncorhynchus tshawytscha) populations. in: Plan for Analyzing and Testing Hypotheses (PATH). Final Report on Retrospective Analyses for Fiscal Year 1996. Prepared by ESSA Technologies Ltd., Vancouver, B.C. for Bonneville Power Administration, Portland, OR. September, 10, 1996

Name: Nick Bouwes
Title: Fish Population Analyst NRS3
Project Position: technical representative for Oregon, stock assessment, and analytical support
Project tasks include modeling and analysis of juvenile life stages, predatation modeling, statistical and decision analysis.
Participation: FTE: .67 FTE (1387hours)
Education:
B.S., University of WI zoology
MS, Utah State University Aquatic Ecology
Ph. D., Utah State University Aquatic Ecology
Current Employer: Oregon Department of Fish and Wildlife 1990-Present. Natural Resource Specialist in the Interjurisdictional Fisheries Management Program Primary Duties: develop analytical models and statistical procedures to assess, monitor, and describe factors limiting naturally produced fish populations. These analytical techniques incorporate and integrate ecology, conservation biology, and population dynamics principles using probabilistic approaches. Participate in an inter-agency modeling and hypotheses testing technical team for Columbia River Basin salmon recovery and rebuilding activities.

Name: Eric Tinus
Title: Fisheries Biologist NRS1
Project Position: technical assistance for Oregon, data base construction, and stock assessment.
Project tasks include Oregon stocks run reconstruction, data base construction and maintenance, stock assessment, and report writing .
Participation: .67 FTE (1387hours **)**
Education:
B.A., German Literature, Reed College (1985)
Biology coursework towards B.S., Biology, Portland State University (1990-91)
Current Employer: Oregon Department of Fish and Wildlife 1990-Present. Conduct stock assessment data reconnaissance, acquisition, summaries, and analyses for salmon, steelhead, sturgeon, and warm water fishes.
Previous Employment: August 1986 - August 1989. Associate with Hobson & Associates, Urban Land Economists, Portland, Oregon. Primary duties: research and assess highest and best uses of developed and undeveloped urban land and recommend strategies to private and public clients for property development or disposition.

Name: Charles E. Petrosky
Title: Fisheries Staff Biologist
Project position: Technical representative for IDFG, stock assessment
Project tasks involve Idaho stocks run reconstruction work, fresh water habitat assessment, hypothesis formulation and testing, decision analysis, and report writing.
Participation: 1 FTE 12 months (2080 hours)
Education

Ph.D. 1984. University of Idaho. Fishery Resources (Supporting Field - Applied Statistics)
M.S. 1973. University of Minnesota. Fisheries (Minor - Entomology)
B.S. 1970. University of Minnesota. Fisheries

Current Employer

Idaho Department of Fish and Game

Current Responsibilities

Provide technical and analytical support to IDFG Fisheries Bureau on anadromous fisheries management issues. Participate in Columbia Basin interagency modeling and analysis of salmon recovery and rebuilding management alternatives. Current process is Plan for Analyzing and Testing Hypotheses--PATH. Specific areas include: spring chinook spawner-recruit analyses, temporal/spatial patterns of productivity and survival rates, freshwater spawning-rearing habitat, steelhead smolt-to-adult survival rate estimation, passage modeling, retrospective analyses, prospective analyses, decision analyses.

Previous Employment

Idaho Department of Fish and Game, Boise, ID
1987-present, Fisheries Staff Biologist: technical, analytical support on salmon recovery
1985-87, Sr. Fisheries Research Biologist: salmon and steelhead natural production studies
University of Washington, Fisheries Research Institute, Grand Coulee, WA
1976-79, Fishery Biologist: fisheries and limnology studies, Banks Lake and Lake Roosevelt
Ichthyological Associates, Pottstown, PA
1973-75, Research Biologist: ecological impact studies

Expertise

stock assessment, salmon biology, freshwater habitat, mainstem passage impacts to fish

Selected Publications

Petrosky, C.E. and H.A. Schaller. 1996. Evaluation of productivity and survival rate trends in the freshwater spawning and rearing life stage for Snake River spring and summer chinook. Chapter 9 in: Marmorek, D.R. and 21 co-authors. 1996. Plan for Analyzing and Testing Hypotheses (PATH): final report on retrospective analyses for fiscal year 1996. Compiled and edited by ESSA Technologies, Ltd., Vancouver, B.C.

Petrosky, C.E. and H.A. Schaller. 1992. A comparison of productivities for Snake River and Lower Columbia River spring and summer chinook stocks. Proceedings of Salmon Management in the 21st Century: Recovering Stocks in Decline. 1992 Northeast Pacific Chinook and Coho Workshop. American Fisheries Society, Idaho Chapter, Boise, ID.

Petrosky, C.E. and T.C. Bjornn. 1988. Responses of wild rainbow (*Salmo gairdneri*) and cutthroat trout *(S. clarki*) to stocked rainbow trout in fertile and infertile streams. Canadian Journal of Fisheries and Aquatic Sciences. 45(12): 2087-2105.

Schaller, H.A., C.E.Petrosky and O.P. Langness 1996. Contrasts in stock recruitment patterns of Snake and Columbia River spring and summer chinook populations. Chapter 3 in: Marmorek, D.R. and 21 co-authors. 1996. Plan for Analyzing and Testing Hypotheses (PATH): final report on retrospective analyses for fiscal year 1996. Compiled and edited by ESSA Technologies, Ltd., Vancouver, B.C.

Weber, E., P. Wilson, H. Schaller, R. Beamesderfer and C.Petrosky. 1996. Internal PATH Review of Williams, Matthews and Myers. 1997. The Columbia River Hydropower System: Does It Limit Recovery of Spring/Summer Chinook Salmon? DRAFT Review Comments, 6/97.

Name: Paul H. Wilson
Title: Biometrician / Modeler
Project Position: CBFWA technical assistance modeling and analytical expertise

Project tasks involve juvenile modeling, life-cycle modeling, statistical analyses, hypothesis formulation and testing, decision analysis, and report writing.
Participation: .90 FTE (1872 hours)
Degrees Earned: (May 1983) B.A. in Environmental Science, University of Virginia. *Graduate work*: (1989-1992) Completed course work for M.S. at School of Fisheries, University of Washington. 1989-1990 Egtvedt Entering Scholar Award Recipient
Current Employer: (1993 to present) Columbia Basin Fish and Wildlife Foundation
Current Responsibilities: Work with multi-agency analytical team that evaluates multi-faceted recovery and rebuilding strategies for Snake River chinook salmon populations . CBFWF Technical Representative to the Plan for Analyzing and Testing Hypotheses (PATH) Project. Study Oversight and Analysis Committee member for the Comparative Survival Rate Study of Hatchery PIT Tagged Chinook Project under the Smolt Monitoring Program..
Recent Previous Employment: (Fall 1992) Teaching Assistant, QSCI/FISH 456 (Fish Population Dynamics) Univ. of Washington, Seattle. (1990-92) Assistant Environmental Analyst Seattle City Light, Environmental Affairs Division, Seattle WA.
Description of expertise: Seven years experience in modeling salmon population dynamics, including population genetics. Five years experience in modeling management strategies for salmon recovery, including developing and updating juvenile passage and life-cycle models. Experienced in programming in several structured programming languages. Monitored and described compliance of major hydroelectric project with fisheries provisions of license agreement, managed development of database application to automate flow compliance of agreement. Wrote research reports of environmental impacts of proposed hydrosystem projects.
Relevant Publications or Job Completions:

Marmorek, D.R. and C. Peters, editors. 1997. Preliminary decision analysis report on spring/summer chinook, 2nd Draft. PATH document, December 19, 1997.

Weber, E., P. Wilson, H. Schaller, R. Beamesderfer, and C. Petrosky. 1997. Internal PATH Review of Williams, Matthews and Myers: The Columbia River hydropower system: Does it limit recovery of spring/summer chinook salmon? Draft review comments. Submitted June, 1997. 18 p. plus figures.

Marmorek, D. and C. Peters (editors) and 24 co-authors. 1996. PATH - Plan for Analyzing and Testing Hypotheses. Conclusions of FY 96 Retrospective Analyses. Prepared by ESSA Technologies Ltd., Vancouver, B.C. for Bonneville Power Administration, Portland, OR. December 10, 1996.

Marmorek, D.R. (editor) and 21 co-authors. 1996. Plan for Analyzing and Testing Hypotheses (PATH). Final Report on Retrospective Analyses for Fiscal Year 1996. Prepared by ESSA Technologies Ltd., Vancouver, B.C. for Bonneville Power Administration, Portland, OR. September, 10, 1996.

Name: Olaf Paul Langness
Title: Fish Biologist 3
Project Position: WDFW technical representative, stock assessment
Project tasks involve Washington stock run reconstruction work, fresh water habitat assessment, harvest analysis, hypothesis formulation and testing, decision analysis, and report writing.
Participation: 1 FTE 12 months (2080 hours)
Degrees Earned: (Dec. 1975) Bachelor of Science in Fisheries, College of Fisheries, University of Washington, Seattle, Washington. (Dec. 1985) Master of Science in Systems Management (Systems Technology), Institute of Safety and Systems Management, University of Southern California, Los Angeles, California (Yokosuka Campus, Japan). *Additional graduate work*: (June 1986 - April 1987) Post-Baccalaureate candidate for Systems Science Ph.D. Program, Portland State University, Portland, Oregon. (March - May 1987) Admitted to Doctor of Public Administration Program, School of Public Administration, University of Southern California, Los Angeles, California (Sacramento Public Affairs Center, Sacramento, California).
Current Employer: Washington Department of Fish and Wildlife, Fish Biologist 3 (ANCOOR/PATH and CSS/Hatchery PIT Tag Projects; special assignments) February 1993 - Present; and, Fish Biologist 2 (Fall Chinook Harvest Management) July 1991- January 1993.

Current Responsibilities: (90 %) WDFW Technical Representative to the Regional Analytical Coordination Work Group (ANCOOR)/ PATH Project. (8 %) Study Oversight and Analysis Committee member for the Comparative Survival Rate Study of Hatchery PIT Tagged Chinook Project under the Smolt Monitoring Program. (2 %) Other duties as assigned (conduct other fisheries management analyses, supervise/participate in other research-monitoring-evaluation projects, etc.).

Recent Previous Employment: Confederated Tribes of the Colville Reservation, Fish and Wildlife Department, Fish Biologist 1 (Off-Reservation Biologist) June 1989- July 1991; and, Temporary Fisheries Specialist (System/Subbasin Planner) June 1988 – June 1989. U.S. Army Corps of Engineers, Walla Walla District, Raceway Biological Technician Fisheries [GS-5] (Juvenile Salmonid Transportation Program) March – June 1988.

Description of expertise: Ten years working in the Columbia River Basin for federal, state, and tribal agencies doing salmon life-cycle and passage modeling, harvest management, system and subbasin planning, and transporting juvenile salmonids.

Relevant Publications or Job Completions:

Schaller, H.A., C. E. Petrosky, and O. P. Langness. 1997. Contrasts in Stock-Recruitment Patterns of Snake and Columbia River Spring and Summer Chinook Populations. Chapter 3 in, Plan for Analyzing and Testing Hypotheses (PATH) Final Report on Retrospective Analyses for Fiscal Year 1996 (David Marmorek, ed.). ESSA Technologies, Vancouver, BC, Canada. 75p.

Langness, O. P. and H.A. Schaller. 1997. Contrasting Stock-Recruitment, Harvest, and Upstream Passage Survival Patterns of the Columbia River Stream-type Chinook Populations. Draft Chapter 13 for the Plan for Analyzing and Testing Hypotheses (PATH) Final Report on Retrospective Analyses for Fiscal Year 1996 (David Marmorek, ed.). ESSA Tech., Vancouver, BC, Can. 41p.

Beamesderfer, R.C.P., H.A. Schaller, M.P. Zimmerman, C.E. Petrosky, O.P. Langness, and L. LaVoy. 1997. Spawner-Recruit Data for Spring and Summer Chinook Salmon Populations in Idaho, Oregon, and Washington. July 1, 1997 Review Draft for the PATH Project. 83p + 152p.

Giorgi, A., C. Paulsen, O. Langness, J. Anderson, L. LaVoy, and C. Peven. 1996. Analysis of Passage Alternatives to Improve Smolt Survival for Ocean-type Summer Chinook in the Mid-Columbia Basin. Report to the Mid-Columbia Habitat Conservation Plan Technical Committee, April 2, 1996. 19p + 77p.

Columbia Basin Fish and Wildlife Authority. 1990. Integrated System Plan for Salmon and Steelhead Production in the Columbia River Basin. Northwest Power Planning Council Report 90-12. 449p.

Name: Earl Weber
Title: Fisheries Scientist
Project Position: CRITFC technical representative, PATH planning group tribal representative
Project tasks involve transportation assessment work, juvenile modeling, hypothesis formulation and testing, decision analysis, PATH planning group coordination, and report writing.
Participation: 1 FTE 12 months (2080 hours)
Education: B.S. in Fisheries Management, The Ohio State University, 1975
M.S. in Fisheries Biology, The Ohio State University, 1977
Current Employer: Columbia River Inter-Tribal Fish Commission
Current Responsibilities: Serve as scientific representative for four treaty tribes in PATH process.
Previous Employment: For ten years prior to my employment at the Commission I was employed with the National Marine Fisheries Service in La Jolla California where I studied the biology and population dynamics of tunas and billfishes worldwide.
Expertise: My current and previous position have required the ability to develop and use mathematical computer models that simulate the life cycles and dynamics of various fish populations. Specifically, I was one of the developers of a system of models that simulate the mainstem passage of salmon stocks through the Columbia and Snake River hydropower system. I have also been involved with several generations of life cycle models that simulate Columbia Basin salmonids.
Recent Publications:

Marmorek, D. and C. Peters (editors) and 24 co-authors. 1996. PATH - Plan for Analyzing and Testing Hypotheses. Conclusions of FY 96 Retrospective Analyses. Prepared by ESSA Technologies Ltd., Vancouver, B.C. for Bonneville Power Administration, Portland, OR. December 10, 1996.

Marmorek, D.R. (editor) and 21 co-authors. 1996. Plan for Analyzing and Testing Hypotheses (PATH). Final Report on Retrospective Analyses for Fiscal Year 1996. Prepared by ESSA Technologies Ltd., Vancouver, B.C. for Bonneville Power Administration, Portland, OR. September, 10, 1996.

Toole, C., A. Giorgi, E. Weber, , W. McConnaha, and anonymous. 1996. Hydro Decision Pathway and Review of Existing Information. Chapter 6.0 in: Plan for Analyzing and Testing Hypotheses (PATH). Final Report on Retrospective Analyses for Fiscal Year 1996. Prepared by ESSA Technologies Ltd., Vancouver, B.C. for Bonneville Power Administration, Portland, OR. September, 10, 1996.

Weber, E., P. Wilson, H. Schaller, R. Beamesderfer and C. Petrosky. 1997. Internal PATH Review of Williams, Matthews and Myers. 1997. The Columbia River hydrosystem: does it limit recovery of Snake River spring/summer chinook salmon? PATH document, submitted June 1997. 19 p. plus tables and figures.

Wilson, P., E. Weber, C. Petrosky and H. Schaller. 1997. Draft proposed general framework for prospective modeling with detailed examples for one hypothesis about delayed mortality. PATH document, submitted August 1, 1997.

Name: Phaedra Budy
Title: Quantitative Fishery Biologist GS 11/1
Project Position: USFWS stock assessment and analytical assistance
Project tasks involve run reconstruction work, statistical analysis, harvest analysis, hypothesis formulation and testing, decision analysis, and report writing.
Participation: 0.5 FTE (1140 days)
EDUCATION: Ph.D. Aquatic Ecology, Utah State University. Dissertation: Adding nutrients to enhance growth and production of endangered sockeye salmon: Trophic transfer in an oligotrophic lake. Chris Luecke- major advisor
Bachelor of Science- University of California, Davis. June 1991 Independent Major in Limnology P.Moyle and C.R. Goldman- advisors.
EMPLOYMENT:1997-present. Quantitative Fishery Biologist. 50% time on the Analytical Work Groupof the Chinook Technical Team (CTC), Pacific Salmon Commission (PSC), 50% time on Plan for Analyzing and Testing Hypotheses (PATH) analyses. Analytical work for the CTC includes annual exploitation analyses based on coded-wire tag data, stock escapement rebuilding assessment, development of abundance based management techniques for PSC fisheries and related analyses, and overall model improvement and evaluation. Current PATH projects include review of PATH prospective analysis for spring/summer chinook, and other associated PATH reports. Direct PATH involvement in retrospective and prospective analyses for fall chinook includes estimating ocean harvest for wild stocks of fall chinook, for run reconstruction and life cycle modeling. A time series of ocean exploitation rates going back to 1977 was completed using the available coded-wire tag data and the models and techniques associated with the (CTC) 1996 Annual Exploitation Analysis; the time series is now being extended beyond the coded-wire tag data back to 1965 using historical data on fishing effort and landed catch.
1996-1997 Utah State University/ Colorado State University/ Puerto Rico LTER - Postdoctoral position, Atyad shrimp population dynamics and conservation genetics. In combination with: Assistant Program Chair for Ecological Society of America-1997.
1992-6 Utah State University, Department of Fisheries and Wildlife, Research Assistant-Ph.D. 1991 Tahoe Research Group, U.C.Davis, Post Graduate Researcher. Duties included sampling nearshore fish distribution and habitat availability/ preference. Hydroacoustic fish assessment. Fish stomach content analysis. Data maintenance, analysis, and presentation. Report writing.
1991-93 Basin Strategies: Planning and Consulting Services. Environmental Assessment, Pier Relocation and Expansion Projects. Describe fish habitat, littoral substratum composition, and any impacts on the fish community. Propose fish restoration sites

and mitigative measures.

PUBLICATIONS

Budy, P. C. Luecke, and W. A. Wurtsbaugh. Adding nutrients to enhance growth and production of endangered sockeye salmon: Trophic transfer in an oligotrophic lake. Transactions of the American Fisheries Society, in press, 1998.

Budy, P. C. Luecke, and W. A. Wurtsbaugh. The effects of whole-lake fertilization on the productivity of an oligotrophic nursery lake for endangered salmon. Ecology, in press, 1998.

Luecke, C., W. Wurtsbaugh, P. Budy, and G. Steinhart. 1995. Simulated growth and production of endangered Snake River sockeye salmon: Assessing management strategies for nursery lakes. Fisheries 26(6):18-25.

Budy, P.Chris Luecke, Wayne Wurtsbaugh, and Howard Gross. 1995. Limnology of Sawtooth Valley Lakes with respect to potential growth of juvenile Snake River sockeye salmon. Northwest Science 69(2):133-150.

Budy, P., Chris Luecke, Wayne Wurtsbaugh, and Howard Gross. 1994. Effects of nutrient enhancement on juvenile sockeye salmon growth. Lake and Reservoir Management, 9(1):140-145.

(Replace this text with your response in paragraph form)

Section 10. Information/technology transfer

Once peer reviews are complete, PATH reports are distributed directly to fisheries managers and the interested public. In addition, the PATH planning group has made five presentation to the NPPC (including members of the public), bimonthly presentations to the Implementation Team, and individual presentations to the ISAB, NMFS, U.S. Army Corps of Engineer Public Round Table, and the Executive Committee. In addition, some PATH analyses have been submitted for publication in the Canadian Journal of Fisheries and Aquatic Sciences.

The tools being developed and improved by PATH, particularly the decision analysis tools, will have tremendous benefits to the region over the next few decades. These will be demonstrated to fish managers, with training provided, in FY99. The results of experimental management work should translate into better design of monitoring programs and evaluation tools.

Congratulations!